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CROPPING SYSTEM STUDIES ON CECIL SOIL

Watkinsville, Ga., 1943-62

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CROPPING SYSTEM STUDIES ON CECIL SOIL, WATKINSVILLE, GA., 1943-62[1]

William E. Adams and Royal N. Dawson[2]

INTRODUCTION

The principal row crops of the Southern Piedmont Plateau are corn and cotton. The greater part of the cultivated land has been seriously damaged by erosion. Thus, the most important and most difficult problems facing the farmers of this area are the conservation and improvement of their cropland. This is a problem requiring the use of cropping systems that will reduce water losses and at the same time improve the productivity of erosion-damaged soil.

Erosion in the Southern Piedmont is due primarily to frequent, high-intensity thundershowers and the resulting runoff of rainfall from land in row crops. These storms occur primarily during the summer growing season and cause approximately 78 percent of the annual soil loss and 54 percent of the annual runoff. It may appear surprising that the actual time during which erosion occurs totals only slightly more than 1 day in 365 days (1).[3]

During the early growth stages of row crops, land is exposed to the direct impact of raindrops, which results in the clogging of pores and in the dispersion, puddling, and surface sealing of the soil. Infiltration is reduced, and runoff and erosion are increased. Earlier studies (6) showed that cover crops, residues, mulches, and cropping systems were very effective in reducing soil and water losses. Terracing and contour tillage were also shown to be desirable practices on classes II, III, and IV land. Terraces break long slopes into shorter slopes, and the effect of contour tillage is to further reduce intraterrace erosion.

CROPPING SYSTEM EXPERIMENTS WITH COTTON (1943-52)

Objectives

Crops were grown in a series of cropping systems on three classes of Cecil soil in order to study the influence of the cropping system on crop yields, soil organic matter, and soil and water losses.

Procedure

Seven cropping systems with cotton and corn were started in 1943 on Cecil soil capability classes II, III, and IV[4]. The cropping systems were replicated three times on each land class. The cropping systems and crop fertilization schedules are shown in appendix table 1. Dolomitic limestone was applied at the rate of 1 ton per acre every 5 years. Nitrogen applications varied with the different crops. All crops in any one cropping system were grown each year. Thus, a 4-year cropping system required four plots per replication. The best adapted crop varieties were planted. All stalks, oat straw, and other crop residues were left on the soil unless otherwise indicated in appendix table 1. The plots were 25 feet wide and varied in length with the terrace spacing. Rows were on the contour.

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[1] Contribution from the Southern Branch, Soil and Water Conservation Research Division, Agricultural Research Service, USDA, in cooperation with the Georgia Agricultural Experiment Stations.

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[3] Underscored numbers in parentheses refer to Literature Cited at end of publication.

[4] In this report the capability class of the Cecil Soil is referred to by the terms "class II land," "class III land," and "class IV land."

Nonuniform distribution of rainfall is also a problem in the Southern Piedmont. Erratic rainfall often causes a reduction of the available moisture supply. Short dry periods of 2 or 3 weeks are common (12). If they coincide with periods of peak moisture use by crops (11), yields are reduced. Less frequent but longer droughts of 4 weeks or more may cause serious crop losses. Thus, conservation and efficient use of moisture are extremely important. Studies of cropping systems on Coastal Plain soils (4) have shown that corn yields following sod crops are higher than those following nonsod crops.

This publication summarizes results of the cropping system experiments at the Southern Piedmont Soil Conservation Field Station, Watkinsville, Ga. The report of these experiments relating to soil and water losses has been published (7), previously.

Cotton Yields

Cotton grown continuously in cropping system (C. S.) No. 1, for 10 years on class II land produced 1,006 pounds per year per acre of seed cotton (appendix table 1). The nitrogen supplied by vetch grown on a winter cover (C. S. No. 2) increased the yield of seed cotton 102 pounds per acre over that of continuous cotton. The 2-year cropping system (C. S. No. 3), cotton-vetch followed by corn and volunteer crotalaria, increased the yield of seed cotton 175 pounds over that of cotton grown continuously. The increase in the yield of cotton in this cropping system may also be attributed to the nitrogen supplied by the vetch and crotalaria. The 3-year cropping system (C. S. No. 5) contained a year of oats and Kobe lespedeza harvested for seed. The lespedeza seed crop residue was left on the soil during the fall and winter. This 3-year cropping system increased the yield of seed cotton 265 pounds, or 26 percent, over that of continuous cotton.

On land class III the production of continuous cotton (C. S. No. 1) yielded 835 pounds of seed cotton per acre per year (appendix table 1). This yield is a reduction of 171 pounds per acre from that of the same practice on class II land and reflects the influence of past erosion and increased runoff from the steeper slope. On land class III, the 2-year cropping system (C. S. No. 3) consisting of cotton-vetch followed by corn-crotalaria and the 3-year cropping system (C. S. No. 5) consisting of oats-Kobe lespedeza, Kobe lespedeza, and corn, each increased cotton yields 20 percent over those of continuous cotton. The 3-year cropping system (C. S. No. 4) increased cotton production by 301 pounds per acre, or 36 percent, over that of continuous cotton. Cotton yields on class III land increased in proportion to the legume residue supplied by the cropping system. Cropping systems Nos. 3 and 4 (appendix table 1) produced more cotton on class III land than on class IV land from which soil and water losses were higher. These two cropping systems do not provide sufficient protection for either class III or class IV land.

Relation of Crop Yields and Land Classes

Differences were noted in the yields of many crops, including cotton grown in all cropping systems on land classes II, III, and IV. Yields of all crops grown in C. S. No. 5 on land classes II, III, and IV decreased as slopes increased (appendix table 1). Cotton yields were approximately

50 percent less on class IV land than on the more gently sloping class II land. The reduction in yields of oats and corn was approximately 30 percent. This 3-year cropping system (C. S. No. 5) has only 1 year of annual lespedeza and appeared to provide ample protection from runoff and erosion for the gently sloping class II land but was inadequate for the steeply sloping land of classes III and IV. The 3-year cropping system (C. S. No. 4) that has 2 years of annual lespedeza provided better protection and produced higher yields of cotton on land classes III and IV (appendix table 1) than did cropping system No. 5.

The soil-improving crops (appendix table 1) were also influenced by land class. Both Kobe lespedeza and sericea lespedeza hay production decreased as the effects of past erosion increased and slopes steepened. These reductions of hay yields may be attributed in part to increased runoff.

Changes in Soil Organic Matter

The cropping system played a major role in influencing the quantity of organic matter in the soil. Organic matter content of Cecil soil, classes II, III and IV land used for five cropping systems was determined in 1943 and again in 1952. Changes in soil organic matter varied widely according to the following tabulation:

Land Class and Cropping System	Change in Organic Matter Percent
Land Class II (Initial organic matter content, 1.30 percent):	
C. S. 1 (continuous cotton)	-0.45
C. S. 3 (cotton-vetch, corn-crotalaria)	- .05
C. S. 6 (cotton-vetch, corn, oats-annual lespedeza, annual lespedeza)	.23
Land Class III (Initial organic matter content, 1.01 percent):	
C. S. 1 (continuous cotton)	-.16
C. S. 3 (cotton-vetch, corn-crotalaria)	-.05
C. S. 4 (cotton, oats-annual lespedeza, annual lespedeza)	+.35
C. S. 6 (cotton-vetch, corn, oats-annual lespedeza, annual lespedeza)	+.35
C. S. 7 (perennial sericea lespedeza)	+1.12
Land Class IV (Initial organic matter content, 0.89 percent):	
C. S. 1 (continuous cotton)	.0
C. S. 7 (perennial sericea lespedeza)	+.89

Wide variations occurred with different cropping practices on the same land class as well as with the same system on the three land classes (5). On land class II, continuous cotton (C. S. No. 1) markedly reduced soil organic matter content, but cropping system No. 3 almost maintained the initial level. Cropping system No. 6 actually increased the soil organic matter.

On land class III cropping systems No. 1 and 3 did not quite maintain this initial level, but the reduction in organic matter for C. S. 3 was not as great as when this cropping system was grown on class II land. The percentage increase of organic matter for cropping systems No. 4 and 6 was higher on class III land than on Class II land. There was a marked gain in soil organic matter content when cropping system No. 7 (continuous sericea lespedeza) was used on class III land.

On land class IV where cotton had been grown continuously for 10 years (C. S. No. 1), there was no change in the level of soil organic matter. However, continuous sericea lespedeza (C. S. No. 7) exactly doubled the initial level of organic matter on this land class.

The increases in soil organic matter were generally closely related to increases in yields of cotton.

Influence of Changes in Cropping Systems on Soil Organic Matter

During the period of this study, several cropping systems were changed on the runoff plots while other plots were cropped to continuous cotton (2). Changes in soil organic matter were determined by annual soil analyses.

One plot used for corn, oats, and 2 years of lespedeza gained in organic matter when changed to cotton, oats, and 2 years of lespedeza but lost organic matter when used for 8 years of continuous cotton. Another plot used for corn followed by 2 years of kudzu maintained its organic matter when changed to corn, oats, and 2 years of fescue.

This increase, maintenance, and depletion of organic matter by cropping systems grown on runoff plots in Cecil clay loam, class IV land, are shown in the following tabulation:

	Organic Matter Content Percent
Plots used for--	
Corn, oats followed by 2 years of Kobe lespedeza, 1943-1948:	
1943	0.7
1948	1.08
Cotton, oats followed by 2 years of sericea lespedeza, 1948-1952:	
1952	1.5
Continuous cotton, 1952-1960:	
1960	.9
Plots used only for continuous cotton, 1943-1960:	
1943	.61
1948	.61
1952	.78
1960	.61

	Organic Matter Content Percent
Plots used for--	
Kudzu, kudzu, corn, 1943-1952:	
1943	0.74
1948	1.26
1952	1.38
Fescue, fescue, corn, oats, 1952-1960:	
1960	1.36
Plot used only for continuous cotton, 1943-1960:	
1943	.74
1948	.74
1952	.78
1960	.76

The soil content of organic matter was dependent on the cropping system as well as the management of the crops in the system. The soil organic matter was maintained at almost a constant level on the class IV land cropped to continuous cotton (C. S. 1) from 1943 to 1960 (see preceding tabulation). The 3-year cropping systems, which included corn, oats-annual lespedeza, annual lespedeza (1943-48) and cotton, oats-annual lespedeza, annual lespedeza (C. S. 4) (1948-52) increased the soil organic matter content, but when these plots were changed to continuous cotton in 1952 the soil organic matter content decreased. In fact, 8 years of continuous cotton reduced the organic matter to almost the same level as it was in those plots that had been continuously cropped to cotton for 17 years.

A 3-year cropping system of corn, kudzu, kudzu also increased the soil organic matter to a level that was approximately comparable to that in plots used for corn, vetch, lespedeza and for cotton, oats, lespedeza. This level of soil organic matter was maintained from 1952 to 1960 after the cropping system was changed to a 3-year cropping system consisting of corn, oats-fescue, and fescue. Continuous cotton maintained the content of organic matter at approximately 0.75 percent during the 17-year period of this study.

The annual lespedezas became very weedy during the last 3 to 4 years of this cotton rotation experiment, whereas the perennials-- kudzu and sericea lespedeza--were free from weeds. The proportion of weeds in the annual lespedeza appeared to increase as soil organic matter content increased.

Summary of Cropping System Experiments with Cotton

A large number of cropping systems with cotton were studied for 10 years on Cecil soil, classes II, III, and IV land. The results are as follows:

1. A 3-year cropping system of cotton-vetch, corn, and oats-Kobe lespedeza (for seed) on class II land increased cotton production 26 percent over that of continuous cotton.

2. A 3-year cropping system of cotton and 2 years of Kobe lespedeza on class III land increased cotton production 36 percent over that of continuous cotton and also increased the soil organic matter content.

3. No one cropping system was found to be ideally suited to classes II, III, and IV land. As slopes steepen, the proportion of close-growing crops to row crops must be increased if crop production is maintained on these land classes.

4. Yields of all crops studied decreased as soil slopes increased.

5. Soil organic matter increased as the proportion of close-growing crops increased in the cropping system.

6. The increases in soil organic matter were generally closely related to increases in yields of cotton.

7. The increase, maintenance, or depletion of soil organic matter was a response to the cropping system used.

8. The annual lespedeza became very weedy during the latter half of the period of study.

PRELIMINARY SOD-BASED CROPPING SYSTEM STUDIES (1948-1952)

The increase in weeds in the annual lespedeza cropping system in the previous experiment prompted the initiation of exploratory studies with sod-based cropping systems on Cecil sandy loam, classes II and III land, in 1948 (appendix table 2). The sods were: Kentucky 31 fescue + whiteclover, smooth bromegrass + whiteclover, rescuegrass + crimson clover, orchardgrass + red clover, and Pensacola bahiagrass + crimson clover.

The objective of this study was to find one or more grasses that would produce a weed-free sod and respond to a higher fertility level than the annual lespedezas.

These preliminary investigations indicated that all the grasses produced a good weed-free sod except bahiagrass, which was slow to establish a good sod; that the sod could be turned and a good seedbed prepared with conventional tractor equipment; that stands were satisfactory for both cotton and corn; and that the cotton yields were at least as good as those in the cotton cropping system experiment reported in appendix table 1.

Forage yields of the grasses in this experiment were approximately double the yield of annual lespedeza in the cotton cropping system experiment shown in appendix table 1. None of the grasses survived tillage and cultivation. All grasses except bahiagrass were easily reestablished by seeding following the row crop. Kentucky 31 fescue appeared to be the most promising of all the grasses studied. Oats were seeded with the grasses following corn or cotton harvest. On one-half of each plot, the oats were harvested for hay and on the other half, for seed. Oats harvested for hay increased weed growth in the grasses; however, oats harvested for hay or seed retarded grass growth in the first year.

CORN SOD-BASED CROPPING SYSTEM EXPERIMENT (1955 and CONTINUING)

The corn sod-based cropping system experiment was initiated in 1955 on Cecil sandy loam, class II land. Previous cropping on the area consisted of several years of rescuegrass and crimson clover harvested for seed and resulted in a high fertility level. Rainfall distribution was poor during July and August, 1955-1958.

Objectives

The objectives of the experiment were to investigate the influence of the several cropping systems on the physical, chemical, and biological properties of Cecil soil; on infiltration and water use; and on the production of corn and forage crops. The design of the experiment permitted to the following evaluations:

1. Continuous corn compared with--

   (a) Corn following grass (rye) winter cover and legume (vetch) winter cover.
   (b) Corn in sod-based cropping systems.

2. The value of applied nitrogen compared with--

   (a) Nitrogen supplied by winter legume (vetch).
   (b) Nitrogen supplied by perennial legume (alfalfa).
   (c) Nitrogen supplied by perennial grass sod.

3. The beneficial effects of--

   (a) Two-year-old sods.
   (b) Three-year-old sods.
   (c) Continuous sods.

4. The relative values of different cropping systems in terms of--

   (a) The nitrogen supplied by the cropping systems.
   (b) The beneficial effects in addition to the nitrogen.

5. The relative effects of a perennial legume (alfalfa) compared with a grass + legume (fescue + whiteclover & Coastal bermudagrass + crimson clover) on soil properties.

6. Effect of rotated sod compared with continuous sod on--

   (a) Soil properties.
   (b) Forage production.

Procedure

The several cropping systems may be grouped as follows:

1. Continuous row crops without winter cover.
2. Continuous row crops with winter cover of legume (vetch) and nonlegume (rye).
3. Four-year sod-based cropping systems consisting of--

   (a) Two years of corn and 2 years of sod.
   (b) One year of corn and 3 years of sod.
   (c) Sods of alfalfa; Coastal bermudagrass + crimson clover; and Kentucky 31 fescue + whiteclover.

4. Continuous sod of alfalfa, Pensacola bahiagrass, Coastal bermudagrass, and Kentucky 31 fescue.

Fertilization consisted of 1,000 pounds per acre of 0-10-20 each year of the rotation (8). Soil pH of about 6.5 was maintained by liming as indicated by annual soil tests. The rye winter cover and all grass sod crops had received 80 pounds per acre of nitrogen. When the rye and sods were turned for corn, the main plots were split for nitrogen levels, which were 0, 40, 80, and 160 pounds per acre of nitrogen (appendix table 3). One-third of each N rate was applied in the row at planting and the remainder as a side dressing when the corn was knee high.

Corn Yields

Corn production without the addition of nitrogen varied widely with the cropping system (appendix table 3). There were three general levels of corn production: continuous corn, 23 bu./acre; corn following rye or following grass-legume sod, approximately 65.1 bu./acre; and corn following a perennial legume sod (alfalfa), 85.3 bu./acre. These differences are highly significant and are attributed to the nitrogen supplied by the cropping system. There were no differences among the several kinds of sod nor among the different ages of the same sod. This fertility reserve associated with grass sods may be utilized by rotating row crops with the sod crops, thus reducing the cost of fertilizer applied to the corn.

Corn production at the higher nitrogen levels varied less widely than at the lower levels (appendix table 3). Continuous corn production at the 80-N level was 67.4 bu./acre. Corn yields following rye winter cover, alfalfa, Coastal bermudagrass, or fescue were significantly higher than continuous corn yields. The increase over continuous corn ranged from 15 to 20 bu./acre. There was no significant difference between corn following rye or the perennial sods. Corn, when well fertilized, produced comparable yields following either a perennial grass or a perennial legume.

The fertility reserve of the sod-based rotations is brought out by comparing the yield of corn obtained without nitrogen following 3 years of alfalfa (appendix table 3) with that obtained from continuous corn at the 80-N level. Corn without nitrogen but following perennial legume sod is 17.9 bu./acre better than continuous corn with 80-N. Even corn production without nitrogen after 2 or 3 years of fescue is comparable to continuous corn with 80-N. Fertilizer alone has not completely overcome the difference in yield between continuous corn and corn in sod-based rotations (3). During good growing seasons when all production factors are most favorable, differences in yield between continuous culture and sod-based rotations may be small. However, in seasons when moisture or unknown factors place stress on corn production, yields may differ more widely for the various cropping systems. These differences usually favor the sod-based rotations.

Influence of Winter Cover Crops

There was no response to nitrogen levels where corn followed vetch winter cover (appendix table 3). Corn production following rye was significantly higher than corn following vetch at the 40-N level and above. The dry weight of rye was three to four times that of vetch at these nitrogen levels.

Influence of Two Successive Years of Corn

Where 2 years of corn followed fescue at the 0-N level, there was a reduction of 20 bu./acre in the second year (appendix table 3). There was no significant reduction in corn yield between the first and second year at the 80-N level. The reduction in corn yield was about the same magnitude whether corn followed alfalfa or fescue. At the 80-N level, first-year corn after fescue was equivalent to the corresponding year and nitrogen level following alfalfa. A similar relationship held for second-year corn yields, which were significantly higher than continuous corn at the same nitrogen level.

Corn Stalk Production, Ear Weight, and Grain-Stover Ratio

The dry weight production of cornstalks varied with nitrogen levels and cropping systems. Cornstalk weights ranged from 2,800 pounds/acre, continuous corn, 0-N, to 7,000 pounds/acre in the sod-based rotations, 80-N. Thus, well-fertilized corn can supply considerable stalk residue.

Ear weight ranged from 0.19 pound for continuous corn grown on 0-N to 0.42 pound for corn following 3 years of fescue at the 80-N level. Ear weight increased with increasing nitrogen levels where corn was grown in continuous culture but was not influenced to any great extent by nitrogen levels where corn followed sod crops.

Grain-stover ratio (pounds of shelled corn per pound of stalk, shuck, and cob) at the 0-N level ranged from 0.57:1 for continuous corn to 1.59:1 where corn followed 3 years of fescue.

Sod-Crop Reestablishment

Coastal bermudagrass was the only sod crop that reestablished itself following corn. This grass survived turning, disking, planting, and cultivating. Sods and alfalfa and fescue required reseeding following corn harvest.

Coastal bermudagrass survival was always sufficient to reestablish a stand following corn. However, the growth of this grass in the corn was generally in inverse relation to the nitrogen levels applied to the corn. Corn population and nitrogen levels appeared to influence the survival of Coastal bermudagrass.

It appears that about 10,000 corn plants per acre and not over 100 pounds of nitrogen per acre allows a good survival of Coastal bermudagrass.

In September 1959 all the corn in this experiment was blown down except that in the Coastal bermudagrass cropping system (C. S. No. 19). This was attributed to the excellent recovery of the Coastal bermudagrass whose stolons appeared to support the corn plants.

Corn wilting was more severe during periods of severe moisture stress in the Coastal bermudagrass cropping system than where corn followed either alfalfa or fescue. However, corn yields were not adversely affected (appendix table 3).

Winter Cover Crops

Residual nitrogen from corn had very little influence on the production of vetch green manure (appendix table 3). However, rye green manure was markedly influenced by nitrogen levels applied to the corn. In fact, rye green manure production was almost doubled from the 0-N level to the 160-N level even though all rye plots received 80-N. The production of rye green manure (dry weight) was from three to four times the production of vetch at any given nitrogen level.

Frequent difficulty was experienced with corn stands following vetch green manure. This was particularly true with a lapse of only 2 weeks between turning the vetch and planting the corn. The trouble appeared to be due to cutworms or to toxic effects from decomposing residues (9, 10) and was observed only in the cropping systems that included vetch.

No serious difficulty was experienced with corn stands where corn followed rye green manure. Where the soil moisture was depleted by a heavy growth of rye, corn germination was occasionally delayed.

Production of Rotated Forage

Although all rotated Coastal bermudagrass plots had received 80-N, the forage production of this grass increased with increasing nitrogen levels applied to corn (appendix table 3). The differences due to residual nitrogen were far more pronounced in the first year of Coastal bermudagrass following corn. The first year of Coastal bermudagrass following corn at the residual 160-N level produced 3.35 tons/acre forage. This level of forage production was maintained in both the second and third years of Coastal bermudagrass following corn. Forage production of this grass continued to increase even in the second and third years following corn at all nitrogen levels (appendix table 3). The increase was greater at the lower nitrogen levels.

The cornstalks were cut following corn harvest, and inoculated crimson clover was broadcast seeded without tillage following corn harvest in October. The cornstalks and Coastal bermudagrass provided grazing for beef cattle during the fall. Inoculated crimson clover was seeded each fall on the Coastal bermudagrass following the last harvest. The crimson clover furnished from 4 to 6 weeks' earlier spring grazing than where Coastal bermudagrass was grown without the clover.

Weeds, especially crabgrass, were present in the first-year Coastal bermudagrass following corn. An occasional mowing reduced the weed competition and aided the spread of Coastal bermudagrass. This grass spread rapidly, especially during periods of good moisture. The second and third years of this grass following corn were free from weeds. Yields reported in appendix table 4 are weed free.

All fescue plots received 80-N. Fescue responded to residual nitrogen from corn in a manner similar to Coastal bermudagrass, but forage production was at a much lower level (appendix table 4). The forage production of rotated fescue improved into the second year following corn.

The stand of whiteclover in fescue declined with increasing nitrogen levels applied to corn the previous year. The whiteclover usually disappeared by the end of the second or third year.

Disease on fescue was most prevalent at the 160-N residual level. This was especially true in 1961 during periods of high humidity.

Production of Continuous Forage

Continuous Forage Compared With Rotated Forage

The forage production of rotated alfalfa was less than that of continuous alfalfa (appendix tables 3 and 4). This reduction was primarily due to reduced production of alfalfa forage the first year following corn. Forage production of second- and third-year rotated alfalfa was comparable to the forage production of fifth- and sixth-year continuous alfalfa.

Rotating Coastal bermudagrass improved forage production. The forage produced by rotated Coastal bermudagrass + crimson clover compared with that by continuous Coastal bermudagrass + crimson clover is shown in the following tabulation. To obtain these yields, 1000 pounds per acre of 0-10-20 and 80 pounds of nitrogen were applied each year. The data are 4-year averages, 1959-62.

	Tons per acre
Continuous Coastal bermudagrass + crimson clover:	
Fifth year	2.77
Sixth year	2.80
Seventh year	2.67
Eighth year	2.76
Total for 4 years	11.00
Rotated Coastal bermudagrass + crimson clover:	
First year following corn	2.73
Second year following corn	3.48
Third year following corn	3.51
Total grass and clover, 3 years	9.72
Corn stalks and ears	4.28

Three years of rotated Coastal bermudagrass produced 87 percent as much forage as 4 years of continuous Coastal bermudagrass. This increase was due to the increased forage production of second- and third-year Coastal bermudagrass following corn. The addition of the whole stalk corn to the 3 years of bermudagrass increased the total forage production of this rotation over that of continuous Coastal bermudagrass.

Rotating fescue also increased forage production (appendix tables 3 and 4) as contrasted to growing fescue continuously. This increase was due to the improved production of second and third years of rotated fescue.

Influence of Nitrogen Level

Forage production of continuous Pensacola bahiagrass + crimson clover, Coastal bermudagrass + crimson clover, and fescue + whiteclover increased as nitrogen levels increased (appendix table 4).

Alfalfa grown without nitrogen produced more forage than fescue and white clover at the 160-N level but was slightly less than bahiagrass + crimson clover and Coastal bermudagrass + crimson clover at the 160-N level.

The forage production of Pensacola bahiagrass + crimson clover at the 160-N was equal to both Coastal bermudagrass + crimson clover at the 160-N level and to fescue + whiteclover at the 320-N level.

At the 320-N level, Coastal bermudagrass + crimson clover produced 28 percent more forage than bahiagrass + crimson clover and 41 percent more than fescue + whiteclover.

Physical, Chemical, and Biological Soil Studies

One objective of this experiment was to determine the influence of sod-based cropping systems on the development and maintenance of desirable physical, chemical, and biological soil conditions and on the efficient utilization of water and plant nutrients.

The physical and chemical soil studies were initiated in 1962, after the plots had been cropped for 8 years in the several cropping systems. These initial soil studies do not permit any definite conclusions about the influence of the soil fertility and the cropping system treatments on soil conditions. Certain trends, however, are evident.

Physical

Nitrogen fertilization has not affected moisture-retention characteristics of the soil. There was a significant decrease in the percentage of water-stable aggregates with increasing levels of nitrogen fertilization.

No significant differences were found in the percentage of pores drained, in bulk density, or in total pore space of the Ap horizon. Highly significant differences in water-stable aggregates existed and were due to the cropping system. Increasing the percentage of sod in the cropping system had the effect of increasing the percentage of water-stable aggregates. Infiltration rates of soils show the following trends:

1. Intake rates increased with the proportion of sod in the rotation.
2. Intake rates were higher after corn was harvested than immediately after corn was planted.
3. High intake rates are associated with high percentages of water-stable aggregates.
4. High intake rates are also associated with high surface detention and with the length of time required to get runoff.
5. Intake rates on continuous grass or alfalfa were lower than those on rotated grass or alfalfa.

Chemical

Soil organic carbon measurements were made in 1962. Carbon increased as the nitrogen rates increased. This is probably a result of increased cornstalk production in response to increasing nitrogen levels. Organic carbon was least in plots used continuously for corn, intermediate in plots used for winter cover crops, and highest in plots used for sod-based rotations.

Biological

Parasitic nematode counts were made in soil samples taken in June and August 1960, 1961, and 1962 by the Nematology Laboratory, Coastal Plain Experiment Station, Tifton, Ga. The population of root-lesion nematodes was higher in August than in June, but the population of other nematodes had not significantly increased. Plots in grass sod generally had fewer root-lesion nematodes. The least nematodes occurred in plots that were in continuous sod. Neither the population nor the species of nematodes was influenced by nitrogen levels or grass species. Vetch appeared to build up the population of parasitic nematodes.

Summary of Sod-Based Experiments with Corn

Eight years of experimentation with corn grown in several cropping systems on Cecil sandy loam, class II land, with the nitrogen levels ranging from 0 to 160 pounds per acre indicate the following trends (appendix table 3):

1. Corn production without nitrogen was--
   (a) Continuous corn (0-N), 23 bushels per acre.
   (b) Corn following rye, either 2 or 3 years of fescue, or 3 years of Coastal bermudagrass, approximately 65 bushels per acre.
   (c) Corn following 3 years of alfalfa, approximately 85 bushels per acre.

2. Continuous corn production at the 80-N level was 67.4 bushels per acre. Corn in the sod-based rotations exceeded this yield by approximately 20 to 25 bushels per acre.

3. Corn production without nitrogen declined approximately 20 bushels per acre in the second year where 2 successive years of corn followed sod. At the 80-N level, the production was not significantly reduced when 2 successive years of corn followed either fescue or alfalfa.

4. Increases in corn production where corn followed sod were largely attributed to the nitrogen supplied by the sod-based rotations and to more moisture in the soil profile.

5. Dry-weight production of rye winter cover (at the 80-N level) was from three to four times that of vetch. Rye production increased as the residual nitrogen from corn increased.

6. Forage production of both rotated Coastal bermudagrass and rotated fescue was proportional to residual nitrogen from corn. Whiteclover in fescue was adversely affected by increasing nitrogen levels that had been applied to corn.

7. Three years of rotated Coastal bermudagrass produced 89 percent as much forage as 4 years of continuous Coastal.

8. Continuous alfalfa produced as much forage as either continuous bahiagrass or Coastal bermudagrass up to the 80-N level and more forage than continuous fescue up to the 160-N level.

9. Forage production of continuous Pensacola bahiagrass was equivalent to that of Coastal bermudagrass up to the 160-N level.

10. Coastal bermudagrass + crimson clover at the 320-N level produced one-third more forage than either bahiagrass or fescue and more than double the forage of alfalfa.

CONCLUSIONS

Seventeen years of experimentation indicate that Cecil soil, classes I and II land, will produce good yields of corn and cotton when grown continuously if the crop is well fertilized and limed and the plant residues are returned to the soil.

However, on steeply sloping soils, classes III and IV land, economic crop production is questionable unless perennial grasses or perennial legumes are included in the cropping system.

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APPENDIX

TABLE 1.--Crop yields per acre as influenced by land classes and cropping system--10-year average, 1943-1952

Cropping system	Crops and use[1]	Yield of seed cotton from land class-			Yield of oats or corn[2] from land class-			Yield of hay[2] [3] or green manure from land class-		
		II	III	IV	II	III	IV	II	III	IV
No.		Lbs.	Lbs.	Lbs.	Bu.	Bu.	Bu.	Tons	Tons	Tons
1........	Cotton...........................	1,006	835	375	--	--	--	--	--	--
2........	Cotton-vetch	1,108	907	--	--	--	--	0.64	0.65	--
3........	(1)[4] Cotton-vetch................	1,181	1,007	--	--	--	--	.66	.64	--
	(2) Corn-crotalaria...............	--	--	--	50	38	--	.37	.36	--
4........	(1) Oats-Kobe lespedeza (seed)...	--	--	--	61	58	38	--	--	--
	(2) Kobe lespedeza (hay).........	--	--	--	--	--	--	1.26	1.17	1.06
	(3) Cotton.......................	1,205	1,136	736	--	--	--	--	--	--
5........	(1) Oats-Kobe lespedeza (seed)...	--	--	--	64	57	42	--	--	--
	(2) Cotton-vetch.................	1,271	1,007	652	--	--	--	.77	.69	.52
	(3) Corn.........................	--	--	--	46	37	28	--	--	--
6........	(1) Oats-Kobe lespedeza (seed)...	--	--	--	58	54	--	--	--	--
	(2) Kobe lespedeza (hay).........	--	--	--	--	--	--	1.61	1.33	--
	(3) Cotton-vetch.................	1,172	1,117	--	--	--	--	.84	.79	--
	(4) Corn.........................	--	--	--	44	43	--	--	--	--
7........	Sericea lespedeza................	--	--	--	--	--	--	--	2.70	2.01

[1] Crops received the following quantities per acre of fertilizer:

Cotton..................................	500 lbs.	6-8-6 + 16-N.
Cotton (with vetch)......................	250 lbs.	6-8-6.
Vetch....................................	250 lbs.	0-8-6.
Corn.....................................	250 lbs.	6-8-6 + 32-N.
Oats.....................................	500 lbs.	0-8-6 + 16-N.
Second-year Kobe lespedeza...............	500 lbs.	0-8-6.

[2] Corn and hay yields are underlined.

[3] Vetch (green manure), crotalaria, and hay yields are corrected to 15-percent moisture.

[4] Number in parenthesis indicates the year in the cropping system in which the crop was grown.

TABLE 2.—Crop yields in the preliminary sod-based cropping system studies—class II land, 1948-1952

Cropping System	Crops and use[1]	Yields per acre of—			
		Cotton	Corn	Oats	Hay[2]
No.		Lbs.	Bu.	Bu.	Tons
8..........	(1) Oats-fescue + clover............	—	—	73	—
	(2) Fescue + clover.................	—	—	—	1.62
	(3) Fescue + clover.................	—	—	—	1.91
	(4) Cotton..........................	1,026	—	—	—
9..........	(1) Oats-fescue + alfalfa...........	—	—	74	—
	(2) Fescue + alfalfa................	—	—	—	2.27
	(3) Fescue + alfalfa................	—	—	—	2.75
	(4) Cotton..........................	1,050	—	—	—
10.........	(1) Oats-orchardgrass + red clover..	—	—	78	—
	(2) Orchardgrass + red clover.......	—	—	—	2.49
	(3) Cotton..........................	1,125	—	—	—
11.........	(1) Oats-fescue + clover............	—	—	66	1.67
	(2) Fescue + clover.................	—	—	—	2.67
	(3) Corn............................	—	48	—	—
	(4) Cotton..........................	1,052	—	—	—

[1] Crops received the following quantities per acre of fertilizer:
Cotton, corn........................... 500 lbs. 6-12-12 + 32-N.
Oats + first-year grass................ 500 lbs. 6-12-12 + 32-N.
Second- and third-year grass........... 500 lbs. 6-12-12 + 32-N.

Lime was applied as needed to maintain a pH of 6.5, according to annual soil tests.

[2] Corrected to 15-percent moisture.

TABLE 3.--Crop yields per acre as influenced by nitrogen level and cropping system--class II land; 4-year average, 1959-1962

Cropping system	Crops and use[1]	Corn yields when nitrogen level in lbs./acre is-				Forage or green manure yields[2] when the nitrogen level applied to corn is-			
		0-N	40-N	80-N	160-N	0-N	40-N	80-N	160-N
No.		Bu.	Bu.	Bu.	Bu.	Tons	Tons	Tons	Tons
12.........	Corn.........................	23.0	64.3	67.4	65.0	—	—	—	—
13.........	Corn-vetch (green manure)....	82.5	67.4	73.4	70.0	0.29	0.38	0.36	0.37
14.........	Corn-rye (green manure)......	65.1	87.9	86.7	90.1	.97	1.11	1.52	1.71
15.........	(1) Fescue + clover..........	—	—	—	—	1.28	1.26	1.27	1.40
	(2) Fescue + clover..........	—	—	—	—	1.77	1.93	1.91	2.14
	(3) Corn.....................	65.2	92.3	87.8	85.3	—	—	—	—
	(4) Corn.....................	45.0	78.7	83.6	77.8	—	—	—	—
16.........	(1) Alfalfa..................	—	—	—	—	2.24	2.30	2.41	2.59
	(2) Alfalfa..................	—	—	—	—	3.68	3.60	3.50	3.55
	(3) Corn.....................	83.3	79.9	80.8	76.8	—	—	—	—
	(4) Corn.....................	64.8	76.0	79.9	77.1	—	—	—	—
17.........	(1) Fescue + clover..........	—	—	—	—	1.42	1.44	1.53	1.57
	(2) Fescue + clover..........	—	—	—	—	1.83	1.77	1.89	2.05
	(3) Fescue + clover..........	—	—	—	—	1.89	1.79	1.86	1.84
	(4) Corn.....................	64.0	87.9	90.8	94.4	—	—	—	—
18.........	(1) Alfalfa..................	—	—	—	—	2.02	2.07	2.17	2.20
	(2) Alfalfa..................	—	—	—	—	3.54	3.71	3.46	3.63
	(3) Alfalfa..................	—	—	—	—	3.75	3.88	3.77	3.70
	(4) Corn.....................	85.3	87.6	84.1	87.1	—	—	—	—
19.........	(1) Coastal bermudagrass + clover................	—	—	—	—	2.36	2.59	2.73	3.35
	(2) Coastal bermudagrass + clover................	—	—	—	—	3.42	3.47	3.48	3.86
	(3) Coastal bermudagrass + clover................	—	—	—	—	3.61	3.62	3.51	3.73
	(4) Corn.....................	67.1	83.8	84.4	86.3	—	—	—	—

[1] Crops received the following quantities per acre of fertilizer:
Corn.......................... 1000 lbs. 0-10-20 + N levels indicated above.
Corn (with vetch or rye)....... 1000 lbs. 0-10-20 + N levels indicated above.
Vetch......................... 1000 lbs. 0-10-20.
Rye........................... 1000 lbs. 0-10-20 + 80-N.
Alfalfa....................... 1000 lbs. 0-10-20 + 20 Borax.
First-, second-, and third-year fescue + clover.............. 1000 lbs. 0-10-20 + 80-N.
First-, second-, and third-year coastal bermudagrass + clover............ 1000 lbs. 0-10-20 + 80-N.
Lime was applied as needed to maintain a pH of 6.5 according to annual soil tests.

[2] The nitrogen levels indicated were applied to corn. All fescue and Coastal bermudagrass plots received 80 lb. nitrogen per acre.

TABLE 4.—Forage production as influenced by nitrogen levels—4-year average, 1959-62

Cropping system	Crops[1]	Forage production per acre when the nitrogen level in pounds per acre is—			
		0-N	80-N	160-N	320-N
No.		Tons	Tons	Tons	Tons
20.........	Alfalfa..........................	2.70	—	—	—
21.........	Fescue + clover..................	1.44	1.80	2.26	3.40
22.........	Coastal bermudagrass + crimson clover..........................	1.95	2.77	3.57	5.81
23.........	Pensacola bahiagrass + crimson clover..........................	2.24	2.91	3.44	4.15

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[1] All crops received 100 lbs. per acre of 0-10-20 annually. Alfalfa got an additional 20 lbs. per acre of borax. Enough lime was applied to maintain a pH of 6.5, according to annual soil tests.